[Name of Document] Patent Application

[Reference Number] P005492

[Filing Date] February 1, 2001

[Attention] Commissioner of the JPO, Kouzo Oikawa

[Inventor]

[Address] 398 Hase, Atsugi-shi, Kanagawa
c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Junya MARUYAMA

[Inventor]

[Address] 398 Hase, Atsugi-shi, Kanagawa
c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Shunpei YAMAZAKI

[Applicant]

[Identification Number] 000153878

[Name] Semiconductor Energy Laboratory Co., Ltd.

[Representative] Shunpei YAMAZAKI

[Indication of Handlings]

[Number of Prepayment Note] 002543

[Payment Amount] 21000

[List of Attachment]

[Attachment] Specification 1

[Attachment] Drawing 1

[Attachment] Abstract 1

[Proof] required

[Document Name] Specification

[Title of the Invention] DISPLAY DEVICE AND MANUFACTURING METHOD THEREOF

[Scope of Claim]

[Claim 1]

A display device characterized by comprising:

a first substrate provided with an organic light emitting element; and

a second substrate which is light-transmitting,

in which the first substrate and the second substrate are bonded using a layer having adhesion,

in which a surface of the second substrate opposing the first substrate comprises a first region and a second region,

in which the first region adheres to the layer having adhesion, and

in which the second region is located inside the first region and concaved relative to the first region.

[Claim 2]

A display device characterized by comprising:

a first substrate provided with an organic light emitting element; and

a second substrate which is light-transmitting,

in which the first substrate and the second substrate are bonded using a layer having adhesion,

in which a surface of the second substrate opposing the first substrate comprises a first region, a second region, and a third region,

in which the first region adheres to the layer having adhesion,

in which the second region is located inside the first region and concaved relative to the first region,

in which the third region is located inside the second region and concaved relative to the second region, and

in which a dry agent is provided in the third region.

[Claim 3]

The display device according to claim 2, characterized in that a moisture-permeable film adheres to a portion of the second region to thereby confine

the dry agent in the third region.

[Claim 4]

A display device characterized by comprising:

a first substrate provided with an organic light emitting element;

a layer having adhesion which encloses with a gap a periphery of a region in which the organic light emitting element is provided over the first substrate; and

a second substrate which is light-transmitting,

in which the first substrate and the second substrate are bonded using the layer having adhesion,

in which a surface of the second substrate opposing the first substrate comprises a first region, a second region, and a third region,

in which the first region adheres to the layer having adhesion,

in which the second region is surrounded by the first region and concaved relative to the first region,

in which the third region is located between the layer having adhesion and an upper portion of the region in which the organic light emitting element is provided and concaved relative to the second region, and

in which a dry agent is located in the third region.

[Claim 5]

The display device according to claim 4, characterized in that a moisture-permeable film is provided between the layer having adhesion and the upper portion of the region in which the organic light emitting element is provided, and the moisture-permeable film adheres to a part of the second region to thereby confine the dry agent in the third region.

[Claim 6]

The display device according to claim 3 or 5, characterized in that the moisture-permeable film adhering to the second region is provided between a plane which is in contact with the first region and a surface of the moisture-permeable film which adheres to the second region.

[Claim 7]

The display device according to claim 2 or 4, characterized in that a difference in height between a bottom portion of the second region which is concaved relative to

the first region and the first region is 10 μm or more and 50 μm or less.

[Claim 8]

The display device according to claim 3 or 5, characterized in that a difference in height between a bottom portion of the second region which is concaved relative to the first region and the first region is 160 μm or more and 350 μm or less.

[Claim 9]

The display device according to any one of claims 1 to 8, characterized in that a difference in height between a bottom portion of the third region which is concaved relative to the second region and the second region is 50 μm or more and 150 μm or less.

[Claim 10]

The display device according to any one of claims 1 to 9, characterized in that the first substrate is a glass substrate.

[Claim 11]

The display device according to any one of claims 1 to 9, characterized in that the first substrate and the second substrate are glass substrates.

[Claim 12]

The display device according to any one of claims 1 to 11, characterized in that a thickness of the layer having adhesion is 10 μm or less.

[Claim 13]

A method of manufacturing a display device in which a first substrate which is light-transmitting and a second substrate are bonded using a layer having adhesion and in which an organic light emitting element is provided over the first substrate, the method is characterized by comprising:

a first step of providing, when a region of the second substrate to which the layer having adhesion adheres is defined as a first region, a first mask in at least the first region;

a second step of digging the second substrate by an abrasive machining method to form a second region which is concaved relative to the first region;

a third step of removing the first mask;

a fourth step of providing a second mask at least in a region of the second

substrate where the first mask is provided and in a region located above a region where the organic light emitting element is provided, and digging the second substrate by an abrasive machining method to thereby form a third region which is concaved relative to the second region; and

a fifth step of providing a dry agent in the third region.

[Claim 14]

The method of manufacturing a display device according to claim 13, characterized by comprising a sixth step of providing a moisture-permeable film in the second region after the fifth step.

[Claim 15]

The method of manufacturing a display device according to claim 14, characterized in that a depth of the digging of the second substrate in the second step is larger than a thickness of the moisture-permeable film.

[Claim 16]

The method of manufacturing a display device according to claim 13, characterized in that a depth of the digging in the second step is 10 μm or more and 50 μm or less.

[Claim 17]

The method of manufacturing a display device according to claim 14 or 15, characterized in that a depth of the digging in the second step is 160 μm or more and 350 μm or less.

[Claim 18]

The method of manufacturing a display device according to any one of claims 13 to 17, characterized in that a depth of the digging in the third step is 50 μm or more and 150 μm or less.

[Claim 19]

The method of manufacturing a display device according to claim 13 or 16, characterized by comprising after the fifth step:

a sixth step of bonding the first substrate and the second substrate using the layer having adhesion; and

a seventh step of cutting the first substrate and the second substrate by a gas

laser.

[Claim 20]

The method of manufacturing a display device according to any one of claims 14 to 16, characterized by comprising after the sixth step:

a seventh step of bonding the first substrate and the second substrate using the layer having adhesion; and

cutting the first substrate and the second substrate by a gas laser.

[Claim 21]

The method of manufacturing a display device according to claim 19 or 20, characterized in that the gas laser is a CO_2 laser.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention pertains]

The present invention relates to a display device using an organic light emitting element, and more particularly to a display device using an organic light emitting element which keeps a stable light emitting property for a long period.

[0002]

Note that the organic light emitting element in this specification indicates an element in which an organic compound is sandwiched between two electrodes to produce light emission. As the organic light emitting element, there is a light emitting element using an organic light emitting diode (OLED). The organic light emitting diode is a light emitter, in which an organic compound is sandwiched between two electrodes, a hole is injected from one electrode, and an electron is injected from the other electrode so that the hole and the electron are combined in the organic compound to thereby produce light emission.

[0003]

[Prior Art]

Recently, a display device using an organic light emitting element is actively researched. In the case of the display device using the organic light emitting element, greater reduction in its weight and thickness is possible as compared with a conventional CRT and an application to various uses is being progressed. Since it is now possible to connect a mobile telephone, a personal portable information terminal (personal digital

assistant: PDA), or the like with the Internet, the amount of information to be displayed has dramatically increased, and the need for color display and high resolution of a display device is increased.

[0004]

On the other hand, it is important for a display device incorporated in such a portable information terminal to be reduced in its weight. For example, in the case of the mobile telephone, a product which weighs less than 70 g is on the market. For weight reduction, a review of most of parts to be used such as individual electronic parts, a case, and a battery is being conducted. However, in order to realize further weight reduction, it is also necessary to promote weight reduction of a display device.

[0005]

A display device in which a pixel portion is formed of an organic light emitting element is of a self light emission type and does not require a light source such as a back light used in a liquid crystal display device. Thus, it is being greatly promised as means for realizing reduced weight and thickness.

[0006]

[Problems to be Solved by the Invention]

With the organic light emitting element, blue color light emission is possible and a self light emission display device capable of full color display can be realized. However, in the organic light emitting element, various deterioration phenomena are recognized, which hinder the practical use. Thus, it is considered necessary to solve such a problem as soon as possible.

[0007]

For example, a dark spot is a point defect of non-light emission, which is observed in a pixel portion, and is recognized as a problem for markedly degrading display quality. It is said that the dark spot is a progress type defect which increases even without operating the element, if moisture is present. It is considered that the dark spot is caused by an oxidation reaction of a cathode formed of alkali metal.

[0008]

Therefore, the display device using the organic light emitting element is constructed with a structure where an element substrate over which a light emitting element is provided and a sealing substrate which is provided so as to oppose the

element substrate are bonded with a seal member, so that the light emitting element is not exposed to outside air. The sealing substrate is made of stainless steel or metal such as aluminum. A dry agent is disposed in a concaved portion of the surface of the sealing substrate.

[0009]

The seal member is mixed with a filler to control a gap between the element substrate and the sealing substrate. Thus, the seal member has both a function for bonding the sealing substrate and the element substrate and a function for controlling the gap between the sealing substrate and the element substrate. Therefore, when the gap between the element substrate and the sealing substrate is set to be 10 μm ~ 50 μm, it is necessary to change the thickness of the seal member in accordance with the size of the gap.

[0010]

Now, the seal member is made of an organic resin material and has higher moisture permeability than a glass material. For example, at a temperature of 60 °C and a humidity of 90 %, moisture permeability becomes 15 $g/m^2 \cdot 24$ hr ~ 30 $g/m^2 \cdot 24$ hr. Even when the sealing substrate and the element substrate are sealed with the seal member, the organic light emitting element is deteriorated by a water vapor which is transmitted through the seal member and enters a sealed region. The amount of water vapor to be transmitted through the seal member is determined by the product of an area of the seal member to be exposed to outside air and moisture permeability. Thus, it is desirable that the area of the seal member to be exposed to outside air is small. That is, it is desirable that the seal member is as thin as possible.

[0011]

Also, a method of thinning a glass substrate may be conceived to achieve weight reduction of the portable information terminal. However, the glass substrate is more likely to break as it becomes thinner, and its shock resistance is reduced. In particular, when the sealing substrate made of metal and the element substrate made of glass are bonded, because of a difference in thermal expansion coefficient, a distortion is caused due to a sudden change in a temperature and a crack is caused in the substrate made of glass. This becomes a critical defect in the case where such substrates are

used for the portable information terminal. Therefore, it is desirable that materials having an equivalent thermal expansion coefficient are used for the sealing substrate and the element substrate.

[0012]

Thus, although the display device including the organic light emitting element is very effective for weight reduction of a display device, there remain problems to be solved in order to ensure the reliability of the organic light emitting element. The present invention is a technique for solving such problems and an object of the present invention is to provide a display device using an organic light emitting element having high reliability.

[0013]

[Means for Solving the Problem]

As the substrate made of glass has become thinner, when the element substrate made of glass and the sealing substrate made of metal are bonded, the possibility that the element substrate made of glass is broken due to a sudden change in a temperature becomes high. In order to prevent this, according to the present invention, a substrate made of glass is used for the element substrate and the sealing substrate to obtain an equivalent thermal expansion coefficient. Thus, resistance thereof against a sudden change in a temperature is increased.

[0014]

Further, according to the present invention, the surface of the sealing substrate made of glass is processed to have a concaved portion and a dry agent is disposed in the concaved portion. Thus, similarly to a conventional case, the dry agent can be provided in a space sealed by the element substrate, the sealing substrate, and the seal member to capture moisture which is transmitted through an adhesion member and enters the space. Calcium oxide, barium oxide, or the like can be suitably used for the dry agent. The dry agent may be provided over, for example, a driver circuit. Then, since the dry agent is present close to the light emitting element in a sealed region between the element substrate and the sealing substrate, entry of moisture to the light emitting element can be reduced. Thus, stability of the light emitting element can be improved. For example, a dark spot caused by oxidation of a cathode can be reduced.

[0015]

Also, according to the present invention, the sealing substrate made of glass is processed so that an outer edge portion of the sealing substrate protrudes in a convex shape. The gap between the element substrate and the sealing substrate is controlled by the convex portion. Then, since a layer having adhesion which is provided between the element substrate and the sealing substrate is required to have only a function for bonding the element substrate and the sealing substrate, a function for controlling the gap becomes unnecessary. Thus, the thickness of the layer having adhesion can be made as small as possible as its material permits. Therefore, the amount of moisture which is transmitted through the layer having adhesion and enters the sealed region can be reduced. It is desirable that the thickness of the adhesion member is 10 μm or less, and preferably, 1 μm or less.

[0016]

An abrasive machining method (sandblast method) can be used as a method of processing the surface of the sealing substrate. The abrasive machining method is a technique of blasting sands, fine steel billets and the like with compressed air to process the surface of a substrate made of glass.

[0017]

One example of the construction of the present invention will be described using Figs. 8(A) ~ 8(C). Figs. 8(A) ~ 8(C) are cross sectional views of a display device using an organic light emitting element of the present invention.

[0018]

Fig. 8(A) shows an example where, in a display device constructed by bonding an element substrate and a sealing substrate with a layer having adhesion, the surface of the sealing substrate is processed and a dry agent and a moisture-permeable film are provided in a sealed region. A first substrate 101 and a second substrate 102 are made from a light-transmitting substrate, for example, a glass substrate. The first substrate is the element substrate, over which an organic light emitting element is provided in a display region 129. The second substrate is the sealing substrate, and the surface thereof is recessed by processing. A dry agent 107 and a moisture-permeable film are disposed thereon. Note that it is desirable the dry agent and the moisture-permeable film be provided outside the display region.

[0019]

Note that, in the present invention, a region located on the same plane as a portion in which a layer 106 having adhesion is bonded to the second substrate is a first region 103 of the second substrate. Also, a region which is concaved relative to the first region is a second region 104. Further, a region which is concaved relative to the second region is a third region 105. In other words, when the second substrate is viewed from the rear surface, the first region is protruded in a convex shape relative to the second region and the third region.

[0020]

The dry agent 107 is provided in the third region 105. A granular material or a flat sheet material can be also used for the day agent. For filling of the dry agent, it is preferable that the third region is recessed by 50 ~ 150 μm relative to the second region.

[0021]

The moisture-permeable film is composed of an adhesive layer 125, a porous layer 126, and a base member 127. In order to confine the dry agent in the third region, the moisture-permeable film is provided so that the adhesive layer 125 contacts with a part of the second region. The moisture-permeable film having a thickness of 150 ~ 300 μm is used. Also, it is desirable that the first substrate is located at a distance 10 ~ 50 μm or more apart from the moisture-permeable film so that the moisture-permeable film is not in contact with the first substrate. Thus, it is desirable that the second region is recessed by 160 ~ 350 μm relative to the first region.

[0022]

Any of an ultraviolet light curable resin and a heat curable resin can be used as the layer 106 having adhesion for bonding the element substrate and the sealing substrate. The amount of moisture entering the sealed region is determined by the product of an area of the layer having adhesion which is exposed to outside air and moisture permeability of the layer having adhesion. Thus, it is desirable that the layer having adhesion is as thin as possible so that the area exposed to outside air is reduced.

[0023]

According to the present invention, since the outer edge portion of the second

substrate is protruded in a convex shape, the gap between the first substrate and the second substrate can be determined by the height of the convex portion of the second substrate. The layer having adhesion is not required to have a function for controlling the gap and thus may be used supplementarily in order to bond the first substrate and the second substrate. Thus, the layer having adhesion can be made as thin as possible insofar as its material permits.

[0024]

Next, another example of the present invention is described. The present invention described below adopts a construction which takes into consideration not only the reduction of moisture which is transmitted and enters through the layer having adhesion but also the reduction of the amount of moisture left in a dry gas in the sealed region.

[0025]

Fig. 8(B) shows a cross section of an organic light emitting element. When compared with Fig. 8(A), a difference from Fig. 8(A) is that the gap between the first substrate and the second substrate is made smaller at 10 ~ 50 μm in the display region 129. The moisture-permeable film is as thick as 150 ~ 300 μm and the gap having such a large thickness is unnecessary in the display region. When the gap in the display region which takes up a predominantly large area of a display device is reduced to 3 % ~ 50 % as compared with that in Fig. 8(A), a volume of a sealed space, that is, a volume of the dry gas is reduced, and which leads to reduction of the total amount of moisture left in the gas.

[0026]

Fig. 8(C) shows an example in which a flat sheet dry agent 107 is provided in the third region 105 of the second substrate 102. Calcium oxide or the like is preferably used for the flat sheet dry agent.

[0027]

In order to prevent mixing of fine powder into the display region which occurs when a portion of the dry agent is removed due to a shock, adhesives 109 are provided in several locations on the surface of the dry agent and a porous film 108 having a thickness of 10 ~ 30 μm is attached to the dry agent using the adhesives 109. Thus,

when a periphery of the dry agent is covered with the porous film, fine powder produced due to a mechanical shock can be confined inside the porous film. It is preferable that the porous film is hollowed in a circular shape in 2 ~ 3 locations to expose the dry agent, and that an adhesive 110 is applied to the exposed portions, so that the dry agent and the second substrate are bonded to each other. The thickness of the adhesive can be set to be 1 ~ 5 μm by controlling the amount of the adhesive to be applied onto the surface of the dry agent. In Fig. 8(C), it is preferable that the thickness of the porous film, the thickness of the dry agent, and the thickness of the adhesive are adjusted so that the dry agent and the porous film can be provided in the third region recessed by 50 ~ 150 μm relative to the second region.

[0028]

In Figs. 8(A) and 8(B), in order not to crash the moisture-permeable film due to weight of the dry agent, it is required that the base member 127 having a thickness of 100 μm ~ 150 μm is provided in contact with the porous film 126 having a thickness of about 10 ~ 70 μm. Further, since the adhesive layer 125 having a thickness of 40 ~ 80 μm is required for adhering the film to the substrate, the thickness of the moisture-permeable film becomes as large as 150 ~ 300 μm. Thus, the amount of moisture left in the gas in the sealed space is increased in correspondence with a volume occupied by the moisture-permeable film.

[0029]

However, in the case of Fig. 8(C), the film is only required to cover the periphery of the dry agent and needs not to have high strength. Thus, even when a thin porous film having a thickness of 10 ~ 30 μm is used, there is no problem for practical use. Also, a volume of the sealed space can be reduced due to the reduction of the thickness of the film. To cover the dry agent, the porous films are provided on a surface opposing the second substrate of the dry agent and on a surface opposing the first substrate thereof. Thus, when the porous film having a thickness of 10 ~ 30 μm is used, the thickness of the porous film within the gap becomes twice as large, that is, 20 ~ 60 μm. Even so, the thickness of the porous film within the gap can be made smaller than the thickness of the moisture-permeable film. If the amount of dry agent is the same, the volume of the sealed region can be reduced with the construction shown in

Fig. 8(C), and thus the amount of moisture left in the gas becomes small. This leads to the suppression of oxidation reaction of the cathode due to moisture and the useful life of the display device can be increased.

[0030]

Note that, in Fig. 8(C), it is preferable that the second region 104 is recessed by 10 ~ 50 μm relative to the first region so that the gap between the first substrate and the second substrate in the display region is set to be 10 ~ 50 μm.

[0031]

Also, in the present invention, since the sealing substrate and the element substrate are light-transmitting, the emitting direction of light from the organic light emitting element provided over the element substrate may be toward either the sealing substrate side or the element substrate side. This can be freely designed in consideration of the light emission area of the organic light emitting element and the like.

[0032]

The present invention based on the above descriptions is as follows.

[0033]

According to the present invention described in claim 1, a display device is characterized by including a first substrate over which an organic light emitting element is provided and a second substrate which is light-transmitting, in which the first substrate and the second substrate are bonded using a layer having adhesion; a surface of the second substrate opposing the first substrate includes a first region and a second region; the first region adheres to the layer having adhesion, and the second region is located inside the first region and is concaved relative to the first region.

[0034]

In the present invention described in claim 1, a portion to which the layer having adhesion is provided is made convex. Thus, a gap between the first substrate and the second substrate can be determined by a convex portion of the second substrate and the layer having adhesion can be used only for the purpose of bonding the first substrate and the second substrate.

[0035]

According to the present invention described in claim 2, a display device is characterized by including a first substrate over which an organic light emitting element is provided and a second substrate which is light-transmitting, in which the first substrate and the second substrate are bonded using a layer having adhesion; a surface of the second substrate opposing the first substrate includes a first region, a second region, and a third region; the first region adheres to the layer having adhesion; the second region is located inside the first region and is concaved relative to the first region; the third region is located inside the second region and is concaved relative to the second region; and a dry agent is provided in the third region.

[0036]

In the present invention described in claim 2, since a portion of the second substrate to which the layer having adhesion adheres is convex, the sealing substrate has a function for controlling the gap, as in claim 1. Further, the dry agent is provided in a concaved portion of the surface of the second substrate to capture moisture penetrated in the sealed region. Thus, the stability of the organic light emitting element is ensured for driving over a long period of time.

[0037]

According to the present invention described in claim 3, a display device is characterized in that, in claim 2, a moisture-permeable film adheres to a part of the second region so that the dry agent is confined in the third region.

[0038]

As in the present invention described in claim 3, a moisture-permeable film may be used as means for providing the dry agent in the third region.

[0039]

According to the present invention described in claim 4, a display device is characterized by including a first substrate over which an organic light emitting element is provided, a layer having adhesion for enclosing with a gap a periphery of a region in which the organic light emitting element is provided over the first substrate, and a second substrate which is light-transmitting, in which the first substrate and the second substrate are bonded using the layer having adhesion; a surface of the second substrate opposing the first substrate includes a first region, a second region, and a third region; the first region adheres to the layer having adhesion; the second region is surrounded by

the first region and is concaved relative to the first region; the third region is located between the layer having adhesion and an upper portion of the region in which the organic light emitting element is provided and is concaved relative to the second region; and a dry agent is located in the third region.

[0040]

In the present invention described in claim 4, a difference from claim 2 is that the dry agent is provided only in a region outside the display region.

[0041]

According to the present invention described in claim 5, a display device is characterized in that, in claim 4, a moisture-permeable film is provided between the layer having adhesion and the upper portion of the region in which the organic light emitting element is provided, and the moisture-permeable film adheres to a part of the second region to thereby confine the dry agent in the third region.

[0042]

As in the present invention described in claim 5, a moisture-permeable film may be used as means for providing the dry agent in the third region. The permeable film is preferably disposed outside the display region.

[0043]

According to the present invention described in claim 6, a display device is characterized in that, in claim 3 or claim 5, the moisture-permeable film adhering to the second region is fit between a plane which is in contact with the first region and a surface on which the moisture-permeable film adheres to the second region. In other words, it is required that the moisture-permeable film is at least not in contact with the first substrate.

[0044]

According to the present invention described in claim 7, a display device is characterized in that, in claim 2 or claim 4, a difference in height between a bottom portion of the second region which is concaved relative to the first region and the first region is 10 μm or more and 50 μm or less. One example of the present invention described in claim 7 has been described already using Fig. 8(C).

[0045]

According to the present invention described in claim 8, a display device is

characterized in that, in claim 3 or claim 5, a difference in height between a bottom portion of the second region which is concaved relative to the first region and the first region is 160 μm or more and 350 μm or less. One example of the present invention described in claim 8 has been described already using Figs. 8(A) and 8(B).

[0046]

According to the present invention described in claim 9, a display device is characterized in that, in any one of claims 1 to 8, a difference in height between a bottom portion of the third region which is concaved relative to the second region and the second region is 50 μm or more and 150 μm or less. One example of the present invention described in claim 8 has been described already using Figs. 8(A) ~ 8(C).

[0047]

According to the present invention described in claim 10, a display device is characterized in that, in any one of claims 1 to 9, the first substrate is a glass substrate.

[0048]

According to the present invention described in claim 11, a display device is characterized in that, in any one of claims 1 to 9, the first substrate and the second substrate are glass substrates.

[0049]

The shock resistance of the substrate decreases as it becomes thinner. Thus, when substrates are made from different materials, a crack is caused in a substrate made of glass due to a sudden change in a temperature. This is a phenomenon resulting from a difference in thermal expansion coefficient. However, when the first substrate and the second substrate are made of the same material as in claim 8, occurrence of a crack due to a thermal shock can be prevented.

[0050]

According to the present invention described in claim 12, a display device is characterized in that, in any one of claims 1 to 11, the thickness of the layer having adhesion is 10 μm or less.

[0051]

According to the present invention, since it is unnecessary to keep the gap by the layer having adhesion, the thickness of the layer having adhesion can be made

infinitely small. It is particularly desirable that the thickness of the layer having adhesion be set to 10 μm or less in order to suppress the penetration of moisture in the sealed region.

[0052]

According to the present invention described in claim 13, a method of manufacturing a display device in which a first substrate and a second substrate which are light-transmitting are bonded using a layer having adhesion and an organic light emitting element is provided over the first substrate, characterized by comprising: a first step of setting a region of the second substrate to which the layer having adhesion adheres as a first region and providing a first mask in at least the first region; a second step of digging the second substrate by an abrasive machining method to form a second region which is concaved relative to the first region; a third step of removing the first mask; a fourth step of providing a second mask in a region over the second substrate in which at least the first mask is provided and a region located above a region in which the organic light emitting element is provided and digging the second substrate by an abrasive machining method to thereby form a third region which is concaved relative to the second region; and a fifth step of providing a dry agent in the third region.

[0053]

An example of the present invention described in claim 13 is described in Embodiment Mode 1 with the use of Fig. 7.

[0054]

According to the present invention described in claim 14, a method of manufacturing a display device is characterized by including, in claim 13, a sixth step of providing a moisture-permeable film in the second region after the fifth step.

[0055]

As a method of providing the dry agent in the third region, there are a method of adhering the dry agent to the second substrate and a method of adhering an adhesive layer of the moisture-permeable film to the second region to thereby confine the dry agent in the third region. Claim 14 is a method used for the latter method.

[0056]

According to the present invention described in claim 15, a method of manufacturing a display device is characterized in that, in claim 14, a depth of the

digging of the second substrate in the second step is larger than the thickness of the moisture-permeable film.

[0057]

According to the present invention described in claim 16, a method of manufacturing a display device is characterized in that, in claim 13, the digging depth in the second step is 10 μm or more and 50 μm or less. According to the present invention described in claim 16, by processing the surface of the second substrate in the structure shown in Fig. 8(C), for example, the second region can be recessed by 10 μm or more and 50 μm or less relative to the first region.

[0058]

According to the present invention described in claim 17, a method of manufacturing a display device is characterized in that, in claim 14 or 15, the digging depth in the second step is 160 μm or more and 350 μm or less. According to the present invention described in claim 17, in the structure shown in Fig. 8(A) or 8(B), the second region 104 can be recessed by 160 μm or more and 350 μm or less relative to the first region 103.

[0059]

According to the present invention described in claim 18, a method of manufacturing a display device is characterized in that, in any one of claims 13 to 17, the digging depth in the third step is 50 μm or more and 150 μm or less. According to the present invention described in claim 18, as shown in Figs. 8(A) ~ 8(C), the third region 105 in which the dry agent is provided can be recessed by 50 μm or more and 150 μm or less relative to the second region 104.

[0060]

According to the present invention described in claim 19, a method of manufacturing a display device is characterized by including, after the fifth step in claim 13 or claim 16, a sixth step of bonding the first substrate and the second substrate using the layer having adhesion and a seventh step of cutting the first substrate and the second substrate by a gas laser.

[0061]

According to the present invention described in claim 20, a method of

manufacturing a display device is characterized by further including, after the sixth step in any one of claims 14 to 16, a seventh step of bonding the first substrate and the second substrate using the layer having adhesion and an eighth step of cutting the first substrate and the second substrate by a gas laser.

[0062]

According to the present invention described in claim 21, a method of manufacturing a display device is characterized in that, in claim 19 or claim 20, the gas laser is a CO_2 laser.

[0063]

The detail of the process of claims 19 ~ 21 will be described later with the use of Fig. 9.

[0064]

Hereinafter, embodiment modes of the present invention are described in detail.

[0065]

[Embodiment Mode of the Invention]

[Embodiment Mode 1]

An embodiment mode of the present invention will be described using Fig. 1. Fig. 1 is a cross sectional view of an active matrix display device using an organic light emitting element.

[0066]

A driver circuit portion 111 and a pixel portion 112 which are composed of TFTs are formed on a first substrate (element substrate) 101.

[0067]

Substrates made of glass such as barium borosilicate glass, aluminoborosilicate glass, or quartz glass are used as the first substrate and the second substrate (sealing substrate) 102.

[0068]

The surface of the second substrate is processed by an abrasive machining method and selectively shaved. By this processing, the surface of the second substrate has a first region 103, a second region 104, and a third region 105. The first region is a surface to which a layer having adhesion adheres. When viewed from a rear surface of the second substrate, the first region is protruded in a convex shape relative to the

second region and the third region.

[0069]

An epoxy system adhesive is used for a layer 106 having adhesion. It is desirable that the layer having adhesion be as thin as possible. LIXSON BOND LX-0001 sold by Chisso Corporation can be also used as the adhesive. LX-0001 is a two-part epoxy resin. After LX-0001 is applied onto the first substrate, while peripheries of the first substrate and the second substrate are pressed, it is cured at 100 °C for 2 hours. A thickness of the adhesive after the curing becomes 0.5 μm ~ 2.0 μm.

[0070]

A dry agent 107 is provided in a concave portion of the third region. Calcium oxide is used for the dry agent. A known material can be used for the dry agent. In this embodiment mode, a planer dry agent is used. A thickness of the dry agent is desirably 10 μm ~ 80 μm. In this embodiment mode, the thickness of the dry agent is set to be 80 μm. The dry agent absorbs moisture entering an organic light emitting element particularly after the first substrate and the second substrate are sealed using the layer having adhesion. Since the dry agent is provided adjacent to a region in which the light emitting element is provided, a concentration of moisture in a sealed region can be reduced and a life of the display device can be extended.

[0071]

In order to avoid moving of fine powder of the dry agent into the pixel portion and the drive circuit portion, a porous film 108 is provided so as to cover the dry agent. An adhesive 109 is applied in dots onto the surface of the dry agent and the porous film adheres to the dry agent. Also, the porous film is cut out in a circle and an adhesive 110 is applied to the thus exposed portion of the dry agent to thereby bond the dry agent 107 and the second substrate with each other.

[0072]

It is desirable that the porous film be as thin as possible. In this embodiment mode, the thickness of the porous film is set to be 10 μm. Also, the thickness of the adhesive can be set to be 5 μm or less, preferably, 1 μm or less by controlling the amount thereof to be applied to the dry agent. In this embodiment mode, the thickness

of the adhesive is set to be 5.0 μm. Since the thickness of the dry agent is 80 μm, when the third region is recessed by about 110 μm relative to the second region, the dry agent 107, the adhesives 108 ~ 109, and the porous film 108 can be provided in the third region.

[0073]

In the pixel portion, the gap between the first substrate and the second substrate is preferably set to be 10 μm ~ 50 μm. In order to set the gap in the pixel portion to be within this range, the second region 104 is preferably recessed by about 10 ~ 50 μm relative to the first region 103. In this embodiment mode, in order to set the gap between the first substrate and the second substrate to be 50 μm in the pixel portion, the second region is recessed by 48 μm relative to the first region. This is a value which is obtained by considering the thickness (2 μm) of the layer having adhesion in this embodiment mode.

[0074]

Since there is a gap of about 50 μm between the porous film 109 and the driver circuit portion, the porous film is not brought into contact with the driver circuit portion 108 and thus TFTs in the driver circuit portion can be prevented from being broken.

[0075]

An organic light emitting element 116 has a structure in which a cathode 113, an organic compound layer 114, and an anode 115 are laminated in order and light emitted from the light emitting element is outputted to the second substrate 102 side. With such a structure, the cathode made of a conductive film having a reflective property can be overlaid over an electrode of a TFT and a wiring, thereby increasing a light emitting area, and obtaining display having high luminance and good visibility.

[0076]

A material including magnesium (Mg), lithium (Li), or calcium (Ca) which has a small work function is used for the cathode 113. Preferably, an electrode made of MgAg (material in which Mg and Ag are mixed at Mg:Ag = 10:1) is used. In addition, it is also possible to use an MgAgAl electrode, an LiAl electrode, and an LiFAl electrode. The cathode is made of a material such as MgAg or LiF. The thickness of the cathode is preferably 100 nm ~ 200 nm.

[0077]

The anode 115 is made of an ITO (indium tin oxide) film that is a light-transmitting conductive film. The thickness of the anode is preferably 100 nm ~ 200 nm.

[0078]

The organic compound layer 114 is obtained by laminating an electron transport layer/ a light emitting layer/ a hole transport layer/ and a hole injection layer in order. However, the organic compound layer may alternatively be obtained by laminating an electron transport layer/ a light emitting layer/ and a hole transport layer or by laminating an electron injection layer/ an electron transport layer/ a light emitting layer/ a hole transport layer/ and a hole injection layer, in the stated order. In the present invention, any known structure may be used.

[0079]

With respect to specific light emitting layers, preferably, cyanopolyphenylene is used for a light emitting layer for emitting light having a red color, polyphenylenevinylene is used for a light emitting layer for emitting light having a green color, and polyphenylenevinylene or polyalkylphenylene is used for a light emitting layer for emitting light having a blue color. The thickness of the light emitting layers may be set to 30 ~ 150 nm.

[0080]

The above example is one example of materials which can be used for a light emitting layer, and the materials are not limited to these. Materials for forming a light emitting layer, a hole transport layer, a hole injection layer, an electron transport layer, and an electron injection layer can be freely selected from possible combinations.

[0081]

TFTs of the driver circuit portion and the pixel portion are provided on a base film 117 having an insulating property. A TFT is composed of a semiconductor film 118, a gate insulating film 118, a gate electrode 119, an interlayer insulating film 121, a drain electrode 122, and a source electrode 123. Preferably, the thickness of the semiconductor layer is set to be 10 ~ 150 nm, the thickness of the gate insulating film is set to be 50 ~ 200 nm, the thickness of the gate electrode is set to be 50 ~ 800 nm, the

thickness of the interlayer insulating film is set to be 1 ~ 6 μm, and the thicknesses of the drain electrode and the source electrode are set to be 200 nm ~ 800 nm.

[0082]

In order to prevent a disconnection in the organic compound 114 and a short circuit between the anode 115 and the cathode 113 due to a disconnection of the organic light emitting element, a bank 124 made of an organic resin such as acrylic or polyimide, preferably a photosensitive organic resin, is provided so as to partially overlap with end portions of the cathode. When the organic compound layer is formed along gradual tapers of the bank 124, the disconnection in the organic compound in end portions of the cathode is prevented and therefore the short circuit between the anode and the cathode resulting from the disconnection in the organic compound layer is prevented. The film thickness of the bank is set to be 1 ~ 3 μm.

[0083]

In this embodiment mode, in order to set the gap between the first substrate and the second substrate in the pixel portion to be 50 μm, the necessary thickness of the layer having adhesion is 2 μm. Thus, an area in side surfaces of the display device in which the organic resin material is exposed to outside air is reduced so that the amount of moisture transmitted through the organic resin material can be greatly reduced as compared with a conventional art.

[0084]

Fig. 7 is a cross sectional view for explaining steps for processing a substrate by an abrasive machining method. There is MB-1 produced by Sintobrator, Ltd. as one example of an apparatus used for the processing.

[0085]

Fig. 7(A) is a cross sectional view showing a state in which first masks 201 are disposed in selective positions on a substrate 202 made of glass before processing. The first mask is disposed in a region in which the layer having adhesion is provided. A film is made adhere to the surface of the substrate, exposed to ultraviolet light, then developed with an alkalescent solution, and dried to thereby form the first mask. An ultraviolet curable type urethane resin is preferably used for the film adhering to the surface of the substrate. This is because of its high shock resistance in the abrasive

machining process. The thickness of first mask is preferably 0.05 mm ~ 0.5 mm.

[0086]

Fig. 7(B) is a cross sectional view indicating a first processing step of performing abrasive machining by jetting fine powder onto the substrate. Fine powder having an average particle size of 3 μm ~ 40 μm is jetted onto the surface of the substrate to selectively remove a portion in which the first mask is not present. After the processing, the substrate is washed to remove processing scraps on the substrate. Thus, a first region 203 and a second region 204 which is recessed relative to the first region can be formed on the surface of the substrate.

[0087]

Fig. 7(C) is a cross sectional view indicating a second processing step of providing second masks 206 on the substrate and performing abrasive machining. Fine powder is jetted to dig the surface of the substrate. Thus, a third region 205 which is recessed relative to the second region can be formed on the surface of the substrate.

[0088]

Fig. 7(D) is a cross sectional view of the substrate after the second masks are removed. In this embodiment mode, a depth of digging in the first processing step is 48 μm and a depth of digging in the second processing step is 110 μm. When the thickness of the substrate before the processing is 0.6 mm, the thickness of the substrate in the first region 203 becomes 0.6 mm, the thickness of the substrate in the second region 204 becomes 0.52 mm, and the thickness of the substrate in the third region 206 becomes 0.41 mm. In this embodiment mode, the second region has the largest occupying area. The thickness of the substrate in the second region is 0.52 mm, which is a preferable value for weight and thickness reduction of a display device. Of course, the thickness of the second substrate before the processing may be set to be 0.6 mm or less so that the weight of the display device can be further reduced.

[0089]

Next, the amount of moisture which can be captured is estimated as follows based on the amount of dry agent provided in the third region. Moisture permeability of the organic resin is 15 ~ 30 $g/m^2 \cdot day$ in an environment of 60 °C and a humidity of

90 %. In this embodiment mode, the moisture permeability of the adhesive is assumed to be 20 $g/m^2 \cdot day$ to estimate the amount of moisture which is transmitted through the adhesive and penetrated in the sealed region.

[0090]

It is assumed that the display device of this embodiment mode has an external shape with a side of 7 cm and a height of the layer having adhesion of 2 μm. An area of the layer having adhesion exposed to air is 0.56×10^{-6} m^2. When an exposed area is multiplied by the moisture permeability, the amount of moisture transmitted per day is obtained as 114×10^{-7} g/day.

[0091]

The total amount of moisture in 10 years is 41.6×10^{-3} g. When calcium oxide is used for the dry agent, the amount of calcium oxide required for absorbing 1 g of moisture is 3 g and the amount of calcium oxide for completely adsorbing moisture in 10 years is 125 mg. Since the specific gravity of calcium oxide is 3.0 g/cm^3, when a volume of the calcium oxide to be filled is 41.7 mm^3, the total amount of moisture which enters through the layer having adhesion in 10 years can be completely adsorbed.

[0092]

The display region has a square shape with a side of 60 mm and widths of the driver circuit portion are 60 mm in a side parallel to the display region and 3 mm in a side perpendicular to the display region. When three driver circuit portions (two gate drivers and one source driver) are provided, an area occupied by the driver circuit portions is 540 mm^2. In other words, when a gap is provided in a position of the sealing substrate corresponding to a region above the driver circuit portions and calcium oxide is filled therein, if the thickness of the dry agent made of calcium oxide is 77 μm, the volume of the dry agent becomes 41.7 mm^3. Thus, the amount of dry agent for completely adsorbing moisture entering through the layer having adhesion in 10 years can be filled. In this embodiment mode, the thickness of the dry agent is 80 μm. Thus, it can be calculated that there exists the amount of dry agent sufficient for a long term usage.

[0093]

The amount of moisture transmitted through a seal member varies according to

a temperature or humidity. Thus, the amount of dry agent used in the present invention may be determined as appropriate according to a use environment of the display device.

[0094]

[Embodiment Mode 2]

In this embodiment mode, an example where a dry agent and a moisture-permeable film are provided over a driver circuit portion is described. In this embodiment mode, points which are different from those in Embodiment Mode 1 will be described in detail. This embodiment mode will be described using a cross sectional view of Fig. 2. Fig. 2 is a cross sectional view of an active matrix type display device using an organic light emitting element. Shown in the drawing is a driver-circuit-integrated structure in which a pixel portion 112 and a driver circuit portion 111 are formed on the same substrate.

[0095]

Substrates made of glass can be used as a first substrate 101 and a second substrate 102.

[0096]

In this embodiment mode, a granular material is used for a dry agent 107. When the dry agent is granular, a surface area thereof is increased and thus it is easier to adsorb moisture. It is desirable that a particle size of the dry agent is set to be 10 ~ 80 μm. In this embodiment mode, a dry agent having a particle size of 30 μm is used. Also, in this embodiment mode, it is assumed that a third region 105 in which the dry agent is provided is recessed by 100 μm relative to a second region 104. Calcium oxide is used for the dry agent.

[0097]

In order to confine the dry agent in the third region 105, a moisture-permeable film which is composed of an adhesion layer 125, a porous layer 126, and a base member 127 is used. Polyester can be used for the base member and a polyfluoroethylene system fiber can be used for the porous layer. NTF1121 produced by Nitto Denko Corporation which has high moisture permeability (moisture permeability of 6800 $g/m^2 \cdot 24$ hr in measurement based on JIS K 7129 Method A) is preferably used for the porous film. Also, the thickness of the moisture-permeable

film is preferably 150 μm to 300 μm. In this embodiment mode, the thickness of the moisture-permeable film is set to be 150 μm.

[0098]

Also, a gap of about 50 μm is provided between the moisture-permeable film and the driver circuit portion so that TFTs in the driver circuit portion are not in contact with the moisture-permeable film. Thus, considering the thickness of the moisture-permeable film and the gap between the moisture-permeable film and the driver circuit portion, the second region 104 is recessed by 200 μm relative to the first region 103. Note that the value of 200 μm is a value which is calculated regarding the thickness of a layer having adhesion and the thicknesses of an interlayer insulating film 121 and a bank 124 as negligible.

[0099]

It is desirable that a layer 106 having adhesion for bonding the first substrate and the second substrate be as thin as possible. In this embodiment mode, the thickness of the layer having adhesion is set to be 1.5 μm.

[0100]

When a volume of the sealed space defined by the first substrate, the second substrate, and the layer having adhesion is decreased in order to reduce the total amount of moisture left in a dry gas in the sealed space, a distance between the first substrate and the second substrate in the pixel portion is preferably set to be shorter than a distance between the first substrate and the second substrate in the driver circuit portion. Since there is no need to particularly provide the moisture-permeable film in the pixel portion, a distance between the substrates in the pixel portion can be arbitrarily determined in consideration of the visibility of a display region and the like. In this embodiment mode, the distance between the first substrate and the second substrate in the pixel portion is set to be 50 μm.

[0101]

In this embodiment mode, an anode 113, an organic compound 114, and a cathode 115 are laminated in this order to form an organic light emitting element 116. A transparent electrode made of ITO is used as the anode. Alkaline earth metal such as MgAg or alkali metal such as AlLi is used as metal having a small work function for

the cathode. Thus, a structure in which light emitted from the organic light emitting element is outputted from the first substrate 101 side is obtained. A hole transport layer, a light emitting layer, and an electron transport layer are laminated in this order to obtain the organic compound. Three kinds of light emitting layers corresponding to RGB are preferably formed to enable color display.

[0102]

When the thickness of the second substrate is set to be 0.7 mm, the thickness of the substrate in the first region becomes 0.7 mm, the thickness of the substrate in the second region becomes 0.5 mm, and the thickness of the substrate in the third region becomes 0.4 mm. In the second substrate, the second region has the largest occupying area. Thus, it may be considered that the thickness or the weight of the second substrate is substantially determined by the thickness of the glass substrate in the second region. In other words, the thickness of the glass substrate in the second region occupying the largest area of the substrate is 0.5 mm, which is a value suitable for reducing thickness and weight of the display device.

[0103]

Also, with the structure according to this embodiment mode, the granular dry agent having a large surface area and high moisture adsorption can be provided in the sealed region using the moisture-permeable film. Also, in this embodiment mode, the dry agent is provided over the driver circuit portion. However, the dry agent can also be provided above the pixel portion. Considering a direction of light emitted from the organic light emitting element, even if the dry agent is provided over the pixel portion, it will not affect the display at all.

[0104]

[Embodiment Mode 3]

This embodiment mode will be described using Fig. 3. In Fig. 3, in a display device in which an organic light emitting element 116 is provided, minute unevennesses are formed on the surface of a substrate through which light emitted from the organic light emitting element is outputted. Hereinafter, this embodiment mode will be described in detail.

[0105]

In this embodiment mode, light from the organic light emitting element 116 is

emitted to the side indicated by an arrow in the drawing. In other words, a user views an image from a second substrate 102 side. At this time, outside light is reflected at an interface between the second substrate 102 and a sealed space and at an interface between the second substrate and air. Thus, reflection of an ambient background view is caused. In order to prevent this reflection, minute unevennesses are formed on the surface of the second substrate.

[0106]

When the surface of the substrate is processed by an abrasive machining method, after forming a first region 203, a second region 204, and a third region 205 on the surface of the second substrate (Fig. 7(D)), a particle size of fine powder jetted onto the surface of the substrate and a jet speed thereof are controlled to form the minute unevennesses on the surface of the first region, the second region, and the third region. The heights of the minute unevennesses are set to be 0.1 μm ~ 3 μm, preferably, 0.1 μm ~ 0.5 μm. In order to prevent diffraction, it is preferable that the unevennesses having different curvatures are provided to improve a scattering property.

[0107]

Also, in this embodiment, in order to prevent the reflection of outside light at an interface between the second substrate and air and the resulting occurrence of reflection of an ambient background when a user views an image formed by the organic light emitting element, an anti-reflective film 128 is formed at an interface between the second substrate and air. In the case of a display device capable of performing color display, light having three colors of RGB is emitted. Thus, it is desirable that the anti-reflective film has a reflectance of 1% or lower, preferably, 0.5% or lower over a wideband wavelength (400 nm ~ 700 nm).

[0108]

According to this embodiment mode, reflection light produced at the interface between the second substrate and the sealed space is scattered by the minute unevennesses. Together with the effect of the anti-reflective film provided on the surface of the second substrate, reflection of an ambient background of the second substrate at the interface of the second substrate can be prevented and it is not recognized by a user.

[0109]

[Embodiment]

[Embodiment 1]

The present invention can be applied to all display devices using an organic light emitting element. Fig. 4 shows one example thereof, and shows an example of an active matrix display device manufactured using TFTs. There is a case where the TFTs in this embodiment are divided into an amorphous silicon TFT and a polysilicon TFT depending on a material of a semiconductor film constituting channel forming region. However, the present invention can be applied to both TFTs.

[0110]

An n-channel TFT 431 and a p-channel TFT 432 are formed in a driver circuit portion 437. A switching TFT 433, a reset TFT 434, a current control TFT 436, and a storage capacitor 435 are formed in a pixel portion 438.

[0111]

As a substrate 401, a substrate made of quartz or glass such as barium borosilicate glass represented by #7059 glass, #1737 glass, and the like produced by Corning Corporation or aluminoborosilicate glass is used.

[0112]

Then, a base film 402 made of an insulating film such as a silicon oxide film, a silicon nitride film, or a silicon oxynitride film is provided. For example, a silicon oxynitride film 402a made from SiH_4, NH_3, and N_2O is formed at a thickness of 10 ~ 200 nm (preferably, 50 ~ 100 nm) by a plasma CVD method. Similarly, a silicon oxynitride hydride film 402b made from SiH_4 and N_2O is formed and laminated thereon at a thickness of 50 ~ 200 nm (preferably, 100 ~ 150 nm). In this embodiment, the base film 402 has a two layer structure. However, it may also be formed as a single layer film of the insulating film mentioned above or as a lamination of two or more layers.

[0113]

Then, island-like semiconductor layers 403 ~ 407, a gate insulating film 408, and gate electrodes 409 ~ 412 are formed. The thickness of the island-like semiconductor films 403 ~ 407 is set to be 10 ~ 150 nm, the thickness of the gate

insulating film is set to be 50 ~ 200 nm, and the thickness of the gate electrodes is set to be 50 ~ 800 nm.

[0114]

Then, an interlayer insulating film 413 having an insulating film made of an inorganic material including silicon nitride, silicon oxynitride, or the like and an insulating film made of an organic material such as acrylic or polyimide is formed. The thickness of the interlayer insulating film is preferably set to be 1 ~ 3 μm. It is desirable that the insulating film made of the organic material has a thickness enough to level unevenness in height caused by the island-like semiconductor films 403 ~ 407 and the gate electrodes 409 ~ 412.

[0115]

Then, a cathode 423 of the organic light emitting element is formed. A material such as MgAg or LiF is preferably used for the cathode. The thickness of the cathode is preferably set to be 100 nm ~ 200 nm.

[0116]

Then, a conductive film containing mainly aluminum is formed at a thickness of 1 ~ 5 μm and etched. Thus, a data wiring 418, a drain side wiring 419, a power supply wiring 420, and a drain side electrode 421 are formed in the pixel portion. The data wiring 418 is connected with the source side of the switching TFT 428. The drain side wiring 419 is connected with the gate electrode 411 of the current control TFT 430. The power supply wiring 420 is connected with the source side of the current control TFT 436. The drain side electrode 421 is connected with the source side of the current control TFT 436 and the cathode. In the driver circuit portion 437, wirings 414 and 416 are connected with the island-like semiconductor film 403 of the n-channel TFT 431, and wirings 415 and 417 are connected with the island-like semiconductor film 404 of the p-channel TFT 432. Note that, in this embodiment, a condition for etching the conductive film mainly containing aluminum is controlled to provide tapers having an angle of 15° ~ 70° relative to the surface of the interlayer insulating film in side surfaces of these wirings. Light emitted from the organic light emitting element in random directions is reflected by these side surfaces of the wirings to thereby prevent total reflection.

[0117]

Then, a bank 422 made of an insulating material is formed so as to cover these wirings. The bank 422 is formed so as to cover end portions of the cathode 423 so that a short circuit between the anode and the cathode in this region is prevented. In this embodiment, a bank made of an inorganic material such as silicon oxide or silicon oxynitride is formed at a thickness of 1 ~ 3 μm. The inorganic insulating film is formed in parallel to taper surfaces of the drain side electrode 421 and the like. Thus, the traveling direction of reflection light is easily estimated based on Snell's law.

[0118]

Then, an organic compound 424 of the organic light emitting element is formed. The organic compound is used with a single layer or a laminate structure. However, when the laminate structure is used, higher light emission efficiency is obtained. Generally, a hole injection layer/ a hole transport layer/ a light emitting layer/ and an electron transport layer are formed in this order on the anode. However, the organic compound may also has a structure such that a hole transport layer/ a light emitting layer/ and an electron transport layer are formed in this order or a structure such that a hole injection layer/ a hole transport layer/ a light emitting layer/ an electron transport layer/ and an electron injection layer are formed in the stated order. In the present invention, any known structure may be used.

[0119]

Note that in this embodiment, color display is performed by a method of vapor-depositing three kinds of light emitting layers corresponding to RGB. As regards specific light emitting layers, preferably, cyanopolyphenylene is used for a light emitting layer for emitting light having a red color, polyphenylenevinylene is used for a light emitting layer for emitting light having a green color, and polyphenylenevinylene or polyalkylphenylene is used for a light emitting layer for emitting light having a blue color. The thickness of the light emitting layers is preferably 30 ~ 150 nm. The above example is only one example of organic compounds which can be used for the light emitting layer, and the materials are not limited to these.

[0120]

Note that the organic compound described in this embodiment has a laminate

structure of a light emitting layer and a hole injection layer, which is made of PEDOT (polythiophene) or PAni (polyaniline).

[0121]

Then, an anode 425 made of ITO (indium tin oxide) is formed. Thus, the organic light emitting element which is composed of the cathode made of a material such as MgAg or LiF, the organic compound in which the light emitting layer and the hole transport layer are laminated, and the anode made of ITO (indium tin oxide) is provided. Note that, when a transparent electrode is used as the anode, light can be emitted in a direction indicated by an arrow in Fig. 4.

[0122]

The outer edge portion of the sealing substrate 427 is convex. By this convex portion, a gap between the first substrate and the second substrate in the pixel portion 438 is controlled. Since the gap is determined by means of the convex outer edge portion of the sealing substrate, the thickness of a layer 439 having adhesion, which is provided between the sealing substrate and the element substrate can be made infinitely small. In this embodiment, the thickness of the layer having adhesion is set to be 1.0 μm.

[0123]

Substrates made of glass are used for the sealing substrate and the element substrate, over which the organic light emitting element 426 is provided. Note that, in this embodiment, the surface of the sealing substrate is processed to provide a dry agent 429 within a sealed region. Thus, similar to the case where a metallic substrate is used as the sealing substrate, moisture in the sealed region can be adsorbed by the dry agent. The dry agent 429 is covered by a porous film 430. The porous film is adhered to the dry agent by an adhesive 428. Also, the porous film is cut out in a circle, and an adhesive 440 is applied to the thus exposed portion of the dry agent to thereby bond the dry agent with the sealing substrate 427.

[0124]

Fig. 5 is a top view of the pixel portion shown in Fig. 4 and reference numerals common to those in Fig. 4 are used for convenience of description. Note that, cross sections taken along lines A-A' and B-B' in Fig. 5 are shown in Fig. 4. Further, the bank is provided outside the regions surrounded by chain lines. Also, the light

emitting layers corresponding to RGB are provided inside the regions surrounded by the chain lines.

[0125]

Fig. 6 shows an equivalent circuit of such a pixel portion and reference numerals common to those in Fig. 4 are used for convenience. The switching TFT 428 has a multi gate structure. LDDs overlapped with the gate electrode are provided in the current control TFT 411. Since a TFT using polysilicon has a high operation speed, deterioration phenomenon such as a hot carrier injection tends to occur. Thus, for manufacture of a display device having high reliability and capable of excellent image display (having high operation performance), it is very effective to form TFTs having different structures (switching TFT in which an off current is sufficiently low and current control TFT which is resistant to a hot carrier injection) in the pixel in accordance with a function.

[0126]

When the dry agent is provided near the organic light emitting element in such a display device using the organic light emitting element, deterioration of the organic light emitting element can be prevented and the stability of the display device over a long period of time can be ensured. Also, since the gap can be controlled by using the sealing substrate, the thickness of the layer having adhesion, which is provided between the sealing substrate and the element substrate, can be minimized. Thus, the area of the layer having adhesion to be exposed to outside air is decreased and thus the amount of water vapor transmitted through the layer having adhesion can be reduced.

[0127]

[Embodiment 2]

In this embodiment, an example of using a CO_2 laser as the severing means, when mother substrates each having an area equivalent to combined areas of a large number of unit panels are bonded to each other and then respective panels are to be severed therefrom, is described.

[0128]

The CO_2 laser is a laser using carbon dioxide as a reactive medium and operated in a population inversion state by causing carbon dioxide to be in an excitation state. Since light having a wavelength of an infrared region (10.6 nm) is generated by

oscillation, an object to be irradiated with laser light can be heated.

[0129]

A method of cutting a glass substrate by using a CO_2 laser will be described using a perspective view of Fig. 9. Fig. 9 is a perspective view indicating a method of cutting one of glass substrates 501 ~ 502 which are bonded together. The glass substrate 501 moving in a direction indicated by an arrow is irradiated with an elliptic laser beam spot by an optical system 504 for irradiating laser, and a coolant is blasted by a nozzle 507 onto a region (cooling region 506) behind the beam spot 503. Thus, when the region heated by laser irradiation is rapidly cooled, thermal distortion is caused within the glass substrate so that the glass substrate 501 is severed along laser irradiation lines 505.

[0130]

A laser scriber produced by Mitsuboshi Diamond Industrial Co., Ltd. can be used as an apparatus for cutting the glass substrate using the CO_2 laser. Two mother substrates may be simultaneously cut or may be cut one by one. It is preferable that two substrates are simultaneously cut because tact of the step is improved and thus productivity is increased.

[0131]

When the surface of the glass substrate is irradiated with laser light from the CO_2 laser so as to be cut, generation of cutting scraps of the glass substrate is suppressed and a resulting operational failure can be prevented. In the method of cutting the substrate using the CO_2 laser, both laser irradiation and coolant blasting are performed in combination so that a shock to the substrate is made small. Thus, when the shock resistance of the substrate is reduced due to the reduced thickness of the display device, the method of cutting the glass substrate using the CO_2 laser is effective.

[0132]

[Embodiment 3]

The light emitting device manufactured by implementing the present invention is incorporated in various electric appliances and the pixel portion is used as an image display unit. As an electronic appliance of the present invention, there are a mobile telephone, a PDA, an electronic book, a video camera, a notebook personal computer, an image reproduction apparatus provided with a recording medium such as a DVD

(digital versatile disc) player or a digital camera, and the like. Specific examples of these electronic appliances are shown in Fig. 10 and Fig. 11.

[0133]

Fig. 10(A) shows a mobile telephone which is composed of a display panel 9001, an operation panel 9002, and a connection portion 9003. A display device 9004, a voice output unit 9005, an antenna 9009 and the like are provided in the display panel 9001. Operation keys 9006, a power source switch 9002, a voice input unit 90058, and the like are provided in the operational panel 9002. The present invention can be applied to the display device 9004.

[0134]

Fig. 10(B) shows a mobile computer or a portable information terminal, which is composed of a main body 9201, a camera unit 9202, an image receiving unit 9203, an operational switch 9204, and a display device 9205. The present invention can be applied to the display device 9205. A display device of 3-inch to 5-inch size is used as such an electronic appliance. When the display device of the present invention is used, the weight of such a portable information terminal can be reduced.

[0135]

Fig. 10(C) shows an electronic book which is composed of a main body 9301, a display device 9303, a storage medium 9304, an operational switch 9305, and an antenna 9306. This electronic book is used for displaying data stored in a mini disk (MD) or a DVD and data received by the antenna. The present invention can be applied to the display device 9302. A display device of 4-inch to 12-inch size is used as the electronic book. When the display device of the present invention is used, reduction in weight and thickness of such an electronic book can be realized.

[0136]

Fig. 10(D) shows a video camera which is composed of a main body 9401, a display device 9402, a voice input unit 9403, an operation switch 9404, a battery 9405, and the like. The present invention can be applied to the display device 9402.

[0137]

Fig. 11(A) shows a personal computer which is composed of a main body 9601, an image input unit 9602, a display device 9603, and a keyboard 9604. The present invention can be applied to the display device 9601.

[0138]

Fig. 11(B) shows a player using a recording medium in which a program is recorded (hereinafter referred to as a recording medium), which is composed of a main body 9701, a display device 9702, a speaker unit 9703, a recording medium 9704, and an operational switch 9705. Note that, with this appliance, a DVD (digital versatile disc), a CD, or the like is used as the recording medium to listen to music, watch movies, play video games or use the Internet. The present invention can be applied to the display device 9702.

[0139]

FIG. 11(C) shows a digital camera which is composed of a main body 9801, a display device 9802, an eye piece 9803, an operation switch 9804, and an image receiving unit (not shown). The present invention can be applied to the display device 9802.

[0140]

The display device of the present invention can be used for the mobile telephone of Figs. 10(A) and (B), the mobile computer or the portable information terminal of Fig. 10(C), the video camera of Fig. 10(D), and the personal computer of Fig. 11(A), and white characters are displayed on a black background in the standby mode, so that power consumption can be suppressed.

[0141]

Also, in the operation of the mobile telephone shown in Figs. 10(A) and (B), brightness is lowered while using the operation keys and then the brightness is increased after the use of the operation keys is finished, whereby power consumption can be reduced. Further, power consumption can be also reduced by increasing brightness of the display device upon receiving an incoming call and then lowering it during a telephone conversation. Furthermore, power consumption can be also reduced by proving a function such that display is turned off based on time control unless reset operation is performed during continuous use of the telephone. Note that these operations may be made by manual control.

[0142]

Although not shown here, the present invention can be also applied to a display device incorporated in a navigation system, a refrigerator, a washer, a microwave oven,

a fixed telephone, a facsimile, or the like. Thus, an application range of the present invention is extremely wide so that the present invention can be applied to various products.

[0143]

[Effect of the Invention]

As described above, when the present invention is used, the gap can be controlled by the convex portion of the sealing substrate and the thickness of the layer having adhesion provided between the sealing substrate and the element substrate can be minimized. Thus, the area of the organic resin material exposed to outside air in the side surfaces of the display device is decreased. Accordingly, the amount of moisture which is transmitted through the organic resin material and enters the sealed region, which is indicated by the product of the area to be exposed to outside air and moisture permeability, can be reduced.

[0144]

Conventionally, in order to provide a dry agent in the sealed region, it has been necessary to bond a metallic sealing substrate and a glass substrate together. Thus, when the shock resistance of the glass substrate is reduced due to its reduced thickness, because of a difference in thermal expansion coefficient between metal and glass, there is a possibility that a distortion is caused by rapid thermal change and the glass substrate is damaged as a result. However, according to the present invention, the sealing substrate and the element substrate can be made of the same material so that the resistance to a thermal shock is improved. Also, since the surface of the glass substrate is processed and the dry agent is provided, as in the conventional art, moisture is adsorbed by the dry agent. Thus, reduction in light emission luminance due to moisture, occurrence of a dark spot, reduction of a light emission area due to enlarged dark spot, and deterioration of the element can be suppressed.

[Brief Description of the Drawings]

[Fig. 1] A cross sectional view of a display device using an organic light emitting element according to Embodiment Mode 1.

[Fig. 2] A cross sectional view of a display device using an organic light emitting element according to Embodiment Mode 2.

[Fig. 3] A cross sectional view of a display device using an organic light

emitting element according to Embodiment Mode 3.

[Fig. 4] A cross sectional view of a display device using an organic light emitting element according to Embodiment 1.

[Fig. 5] A top view for explaining a structure of a pixel portion of a display device using an organic light emitting element according to Embodiment 1.

[Fig. 6] An equivalent circuit of a pixel portion of a display device using an organic light emitting element according to Embodiment 1.

[Fig. 7] Cross sectional views indicating a method of manufacturing a sealing substrate in Embodiment Mode 1.

[Fig. 8] Cross sectional views of a display device using an organic light emitting element according to the present invention.

[Fig. 9] A perspective view indicating a method of cutting a glass substrate using a CO_2 laser.

[Fig. 10] Explanatory views of examples of electronic appliances.

[Fig. 11] Explanatory views of examples of electronic appliances.

[Document Name] ABSTRACT

[Summary]

[Problem] In a display device using an organic light emitting diode (OLED), the occurrence of a dark spot and peeling of a cathode due to moisture are suppressed.

[Solving Means] An outer edge portion of a sealing substrate is made to have a convex shape and a gap between the sealing substrate and an element substrate is controlled by means of this convex region. Thus, since it is not required that a layer having adhesion for bonding the sealing substrate and the element substrate has a function for controlling the gap, the thickness of the layer can be minimized. Therefore, the amount of moisture which is transmitted through the layer having adhesion made of an organic material and enters a sealed region can be reduced.

[Selected Drawing] Fig. 1